Quantitative study of poplar plantations in three Iranian provinces

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Abstract Fast growing poplar species enjoy a highly favored position in Iran's forest product industries. However, information on poplar plantations, such as areas, growing stock and harvest volumes, are largely obtained by non scientific means and poorly executed methods. A few studies have been conducted to obtain data on the capacity of poplar plantations, their extent, existing growing stock, distribution and species choice in three provinces, i.e., Western Azerbaijan, Kurdistan and Hamedan, with relatively well developed management systems. We opted for a cluster method, a standard sampling method for conducting similar investigations, consisting of two phases. In the first phase we collected library information and conducted half-open interviews with villagers. In the second phase field measurements in the villages of these three provinces were carried out. Information from field measurements on growing stock, cultivated areas, dominant species were used to estimate volumes by way of volume and weight tables. Results obtained from the present study indicate that the average annual volume of timber harvested in the three provinces was 697,723 m³, with an average sampling error of 22.7 per cent. This annual volume of poplar timber harvested from the three provinces was estimated to amount to about 25 per cent of overall harvest; at that rate, the overall annual utilization potential of poplar plantations will be 10 million m³, which constitutes a reliable resource of raw timber for use in wood and paper industries.

Keywords poplar plantations, field measurements, harvest volumes, cluster sampling

Introduction

Considering the demand for wood product in the country and our present inability to produce sufficient timber from our northern forests, we need to continue to manage existing poplar plantations and resort to establishing new ones in Iran. However, a number of factors have prevented the development of poplar plantations in various regions of the country; at the same time over-harvesting of poplar has occurred and the cut-over forests have changed into agriculture land. The volume of timber production from poplars in 1993 exceeded two million m³. After 11 years, the 2003 statistics for wood production from plantation forests shows only a small increase (i.e., from 2 million to 2.5 million m³ per year). Changes in area, standing volume and annual harvests can partly determine the future development of wood products. In the mean time, by identifying suitable poplar species for different regions, the possibility of optimal use of this wood for various industrial applications should be provided. In Iran, various wood industries,

such as veneer and plywood mills, sawmills (for rough lumber production and scaffolding boards, hydro and telephone poles and mining timber) as well as the pulp and paper industry, use poplar wood. Poplar wood satisfies our rapidly increasing industrial needs which are the cause of the gradual destruction of forests.

Since poplar, as the source of wood, is of great importance for use in the pulp and paper industry, it is necessary to create an appropriate database for identifying this important wood material in terms of area, inventory, distribution, species and harvest volumes. However, up to date, access to such information and statistics for scientists and industrialists for industrial applications has met with great difficulty. In developed countries databases regarding wood material are accessible, up to date and available at low cost. In Iran, in spite of being rich and with various regions endowed with naturally occurring poplars, there are no appropriate databases for easy and quick access to information and hence, the generation of databases is very important and vital for our country. Therefore, in this study, to answer some of these questions and satisfy our requirements, the status of poplar timber in three highly productive provinces has been studied and analyzed.

Several studies have been conducted on the importance of poplar and its applications. Balatinecz and Kretschmann (2001) specified that the use of round poplar wood in North America in 1989 was four times larger than that in 1975. Its applications include pulp, lumber, pressed boards, insulation boards, cover and veneer layers, wood composite material (chip board and wafer board), structural composite lumber (laminated lumber), pallets, furniture, fruit baskets and shelves. The consumption of poplar wood actually exceeds the annual yield from its plantations in North America. Most research has focused on breeding of poplar trees in terms of growth rate, appearance, compatibility and resistance to drought, but little in the way of its modified wood. Compared to local species, poplars have more uniform mechanical properties, faster growth and more juvenile wood. Subtle features such as those of filter and printing paper made from poplar are excellent

and suitable for a variety of uses. To be sure, there are some disadvantages in the use of poplar wood, which has the potential of early decay, discoloration and problems with kiln drying (especially those with wet holes). Despite those problems, Davision and Riggs (2004) asserted that the application of poplar trees, such as in wood and paper production, is very extensive. Since the commercial value of pulp made from poplar has decreased, new applications of modified poplar wood have been developed, such as in furniture use, pallets, decorative wood (where the core material is covered with a coating), layer boards, chip boards, directional boards, wafer and laminated lumber.

Mills (2001) found that demand for wood is affected by changes in areas set aside for timber plantations, their operation, management and timber harvest as well as by increased consumption. In the future, the use of wood in residential and commercial buildings will increase, which will necessitate increase in investments in forests, giving rise to an even greater increase in the demand for wood products. Softwood lumber production in 1990 decreased more than half in USA. After 1996, utilization of wood in agriculture increased. Therefore, increased investment in timber production is expected. The number of forest product manufacturing industries in Turkey, in the period from 1990 to 1999, has increased considerably, satisfying important business objectives. A number of different forest products exported from Turkey and the number of countries with which it has trade relations, has increased to 139 up until 1999. Turkey's manufacture of forest products include wood, lumber, wood frames, wood coatings, pipe cuttings and packing material, furniture, as well as the production of non-wood forest products, building material and structures (Huseyin and Ahmet, 2001). Investigation of the market for small-diameter poplar wood and wood products in Iran shows that the dependence on poplar of manufacturers of wood products has greatly expanded and hence, any fluctuation, problem and potential changes in the conditions of the poplar timber market can be transferred to wood product markets (Bayatkashkooli, 2006).

The aim of our study is to identify resources

and capacities of the different regions of the country in terms of poplar plantations and to provide comprehensive information to investigators and investors in the proper utilization of this valuable species. In order to achieve this goal, characteristics such as the method of distribution, areas, growing stock, harvest volumes and species of poplar suitable in three provinces, i.e., Western Azerbaijan, Kurdistan and Hamedan, were determined and analyzed.

Materials and methods

Based on previous studies, three provinces, i.e., Kurdistan, Western Azerbaijan and Hamedan, were selected as our areas of investigation, due to their high prevalence of poplar plantations, their many factories or workshops, as well as their high levels of consumption, production and export of poplar wood. A map of the provinces is presented in Fig. 1. A two-phase cluster sampling method was used. In the first phase, we collected library information and conducted half-open interviews in rural areas. In the second phase we conducted field surveys in villages of the three provinces. Hence a general list of the towns and villages in each province was obtained, based on information from the Iran Oasis Records Book (2007). Villages of these provinces were classified in six

Fig. 1 Map of provinces studied (A = Western Azerbaijan, K = Kurdistan, H = Hamedan), scale of 1:2,500,000

different groups, i.e., flat, mountainous, plain and mountainous, plain and forest, mountain forest and miscellaneous areas. In order to represent the entire community, about 30 villages in different cities of each province were selected at random. The number of selected villages in each city was proportional to their populations. Based on addresses obtained from government offices in each province regarding the regions selected, telephone interviews were carried out. Then necessary adjustments were made in selected villages. Information such as area and the amount of the annual harvests was collected from each village. The second phase included selecting villages for the field survey. Six villages from 30 villages were selected randomly from each province in order to carry out field survey.

Data collected from the field surveys consisted of the following: 1) areas cultivated with poplar, 2) poplar growing stock, 3) dominant species in each region and 4) diameter and height measurements and estimates of volume harvested by volume and weight tables. The number of poplar trees per ha, average diameter and height of cut and growing stock of poplar for calculating areas, volumes and weights were determined. Criteria for measurements and calculations were tall trees with a diameter of 10 cm or larger. Volumes were determined from volume tables calculated by Bagheri (1997) for poplars in Iran and by Mirsadeghi and Hedayati (1988) for poplars in Turkey. To obtain weights, special weights calculated by Bagheri (1997) for poplars in Iran were selected.

According to information obtained from interviews and field surveys, this information could be extended to the entire area of each province with a definite estimate of sampling error. The areas cultivated with poplar were obtained by multiplying the average cultivated area with the total number of villages in each province; annual harvest volumes were obtained according to the same rule. To determine the sampling error, the field survey was considered as the base of our investigation. The error percentage was obtained from equation (1):

$$EP = (A_I - A_F)/A_F \times 100 \qquad 1)$$

where EP is the error percentage (for area or annual harvest), A_I the area or annual harvest

based on interviews and A_F the area or annual harvest of our field surveys.

Results

Based on information gathered from the Iran Oasis Records Book (2007), we determined that the total number of rural villages is 1,119 in Hamedan Province, 1,756 in Kurdistan and 2,316 in Western Azerbaijan. According to the field survey, the dominant species in Hamedan and Kurdistan provinces is *Populus nigra* and *Populus alba* in Western Azerbaijan.

The number of poplar trees per ha varied among the three provinces. The density of poplar trees in Hamedan was greater than that of the other two provinces. The number of trees of the three provinces, based on our field survey, is presented in Table 1. Volume and average weight of each of the standing poplar trees were calculated based on their average diameter and height by using volume tables for poplar species (Davision and Riggs, 2004) and average density (526 kg·m⁻³; Bagheri, 1997) for each province.

Table 1 Number of trees in specified area of Hamedan, Western Azerbaijan and Kurdistan provinces

	Hamedan		Western Azerbaijan		Kurdistan	
	Area (m²)	Number of trees	Area (m²)	Number of trees	Area (m²)	Number of trees
1	1,000	600	500	200	4,000	1,350
2	500	280	6	10	100	40
3	1,100	600	120	250	5,000	1,400
4	1,300	480	4	4	7,000	2,000
5	700	500	4	15	400	150
6	600	230	10,300	1,950	6	4
7	1,500	700	10,000	1,650	8,000	2,000
8	150	96	14,000	1,824	2,000	700
9	1,000	450	4	14	15,000	5,000
10	1,300	748	560	3,750	10,000	4,000
11	500	300			600	150
12	600	120			900	300
Mean	854	425	3,550		4,417	1,425
Number of trees per ha	4,980		3,230		3,226	

Table 2 shows the average height, diameter, volume and average weight of standing trees by using different methods. Similarly, the average volume and weight of each of the harvested trees for each province were calculated, as shown in Table 3.

The area of cultivated poplar plantations, volume and weight of standing poplar trees of each province are listed in Table 4. As can be seen from this table, the area of poplar plantations in Western Azerbaijan (18,281 ha) was more than that of the other two provinces (8,482 and 5,508

Table 2 Average diameter and height of standing poplar trees and their average volumes and weights

	Hamedan		Western Azerbaijan		Kurdistan	
	Height (m)	D (cm)	Height (m)	D (cm)	Height (m)	D (cm)
1	12.6	10.2	10.5	21.0	15.5	24.0
2	13.2	12.2	13.5	29.0	13.0	22.0
3	14.8	15.1	14.0	27.5	10.5	18.5
4	14.8	24.2	15.5	31.0	14.5	25.0
5	16.4	17.7	17.0	32.0	8.0	12.2
6	21.4	37.4	13.5	34.0	10.0	16.0
7	17.0	17.4	18.0	30.0	12.5	19.2
8	12.6	12.2	10.5	28.0	8.0	14.1
9	15.6	15.7	5.0	13.0	9.0	15.2
10	22.6	24.4	3.0	9.0	9.5	15.6
11	12.5	18.9	4.5	10.0	11.0	16.1
12	25.6	38.8	4.0	11.0	8.0	5.0
13			6.0	11.0		
14			8.0	15.0		
15			6.0	10.0		
16			5.0	10.5		
Mean	16.6	20.4	9.6	20.1	10.8	17.7
Volume¹ (m³)	0.24		0.16		0.13	
Volume² (m³)	0.14		0.09		0.10	
Mean volume (m³)	0.19		0.12		0.11	
Weight¹ (kg)	127.00		81.79		69.20	
Weight² (kg)	76.00		47.86		51.00	
Mean weight (kg)	101.50		65.00		60.10	

Note: *D* means diameter. The density is 526 kg·m⁻³. 1 means estimate based on Bagheri's method (1997); 2 means estimate based on method by Mirsadeghi and Hedayati (1988). The same comment applies to Table 3.

Table 3 Average diameter and height of harvested poplar trees and their average volumes and weights

	Hamedan		Western Azerbaijan		Kurdistan	
	Height (m)	D (cm)	Height (m)	D (cm)	Height (m)	D (cm)
1	17.0	20.0	14.5	24.0	11.0	17.0
2	17.0	14.0	10.5	29.0	14.0	19.5
3	17.0	25.0	15.5	17.0	12.0	21.0
4	15.0	22.0	14.0	12.0	10.0	15.5
5	18.0	19.0	12.0	11.0	16.0	23.5
6	15.0	20.0	18.0	40.0	13.0	19.0
Mean	16.5	20.0	14.1	22.2	12.7	19.3
Volume^1 (m^3)	0.24		0.26		0.17	
Volume^2 (m^3)	0.14		0.12		0.11	
Mean volume (m^3)	0.19		0.19		0.14	
Weight^1 (kg)	127.00		135.00		92.00	
Weight^2 (kg)	76.00		62.00		60.00	
Mean weight (kg)	101.50		98.50		76.00	

ha).

The volumes and weights of the annual poplar harvest in the three provinces, according to the interviews, are presented in Table 5. Cultivated areas and the annual harvest of poplar, along with the estimates of possible errors (in %) for each province, are provided in Tables 6–8.

Discussion

The results of Tables 6–8 show that in the three poplar rich provinces, i.e., Hamedan, Western Azerbaijan and Kurdistan, the areas of poplar plantation are 10,723.75, 26,055.00 and 7,317.25 ha, respectively; the percentage errors obtained on the basis of a comparison between the two methods, i.e., interviews and field surveys, were 20.90%, 32.84% and 24.73%, respectively. The annual harvest volume in the three provinces was 1,359,585 m^3 for Hamedan, 703,733 m^3 for Western Azerbaijan and 29,852 m^3 for Kurdistan and their percentage errors were 38.67%, 18.98% and 10.66%, respectively, suggesting that in both cases the error obtained are relatively acceptable.

The percentage errors were calculated for areas and volumes of annual harvests. In the case of the area of poplar plantations, Western Azerbaijan Province was given a higher priority than the other two provinces. On the other hand, in terms of annual harvest volumes, Hamedan Province had the higher priority, suggesting that this province has higher density of poplar plantations. It is shown that the area of polar plantations in the entire country was 150,000 ha, while that of our three provinces was 44,095 ha, accounting for about 29% of the total area of poplar plantations in Iran (WITO, 1992).

Given the results obtained from Table 4, the total volume of standing poplar in the three provinces was approximately 17.4 million m^3; compared with our calculation of 12.3 million m^3, there was a 30% increase in the volume of standing timber compared to the past decade. Therefore, the conditions in the three provinces,

Table 4 Cultivated areas, volumes and weights of standing poplar in three provinces based on interviews

Hamedan	Area (ha)	Volume 0.1925 (m^3)	Weight 101.5 (kg)
Mean	7.58	7,266.40	3,831,373.00
Total	8,482.00	8,131,098.00	4,287,305,991.00
Western Azerbaijan	Area (ha)	Volume 0.1233 (m^3)	Weight 65.0 (kg)
Mean	7.90	3,142.32	1,657,205.33
Total	18,281.00	7,277,604.00	3,838,087,552.00
Kurdistan	Area (ha)	Volume 0.1143 (m^3)	Weight 60.1 (kg)
Mean	3.14	1,156.21	608,209.71
Total	5,507.99	2,030,304.70	106,801,625.00

Table 5 Annual volume and weight of poplar trees harvested in three provinces based on interviews

Hamedan	Annual harvest (t)	Volume 0.1925 (m^3)	Weight 101.5 (kg)
Mean	6,015.37	784.37	372,218.17
Total	416,941.10	877,707.56	416,512,132.00
Western Azerbaijan	Annual harvest (t)	Volume 0.1865 (m^3)	Weight 98.5 (kg)
Mean	180.76	162.34	85,740.97
Total	418,634.70	375,984.15	198,576,079.00
Kurdistan	Annual harvest (t)	Volume 0.1440 (m^3)	Weight 76.0 (kg)
Mean	9.41	18.95	9,525.31
Total	16,517.17	31,692.29	16,726,440.00

Table 6 Cultivated areas and volumes of annual poplar harvest, with potential error percentages based on the results of field surveys and interviews in Hamedan Province

Village	Area (ha)	Annual harvest (t)
Baba pir ali	10.00	150.0
Dolat abad kamalvand	8.50	75.0
Damagh	7.00	1,800.0
Abro	14.00	100.0
Ghahverde olia	3.00	20.0
Mahdavieh	15.00	1500.0
Average	9.58	607.5
Total	10,723.75	679,792.5
Error percentage	20.90%	38.67%

Note: The total number of villages in Hamedan is 1,119.

Table 7 Cultivated areas and volumes of annual poplar harvest, with potential error percentages based on the results of field surveys and interviews in Western Azerbaijan Province

Village	Area (ha)	Annual harvest (t)
Aghcheh loo	15.00	300.0
Sothern Marhamat abad	2.00	22.0
Nazloo	20.00	90.0
Bigham ghal'eh	5.20	40.0
Taghi abad	3.50	11.5
Ahmad abad (ghet'eh ghahan)	20.00	500.0
Koozeh konan	4.50	100.0
Average	11.25	151.9
Total	26,055.00	351,866.6
Error percentage	32.84%	18.98%

Note: The total number of villages in Western Azerbaijan is 2,316.

with regard to their poplar plantations, have improved. Furthermore, compared to the past decade, although the number of industries using poplar wood has been increasing over this period, the knowledge of workers about the profitability of poplar species and their reforestation has also increased and this level has somewhat been preserved. If the annual harvest in the three provinces were considered to be about 25% of the total harvest from poplar plantations, we can conclude that the potential annual harvest from poplar plantations of the whole country is about 10 million m³ which can be a reliable

source of raw wood for pulp and paper industry in the country. Of course we can make this claim only when the planting of poplar is sustained. Calculations to determine the volume of harvests was based on the wet weight of trees, but this can be converted to dry weight at the stage of their industrial use. Based on the results from these three provinces, with an average harvest of about 45 m³ of timber per ha and given their high volume of standing timber, this rate of harvesting seems reasonable and sustainable. But it should be pointed out that this rate of harvesting timber does not necessarily correspond to the annual calculated yield of these plantations. The rate of timber harvesting is a function of market conditions regarding prices and demand for wood. In traditional poplar plantings, farmers respond to increase in the prices by immediately harvesting their trees and send them to market. Hence, their harvest does not match their annual growth. In order to decrease the risk of raw material shortages, given the current situation, it is necessary to establish a link between rates of growth and farmers with their poplar plantations, in case relevant governmental agencies and wood and paper industry authorities are planning to establish new manufacturing facilities or expand existing units. This relationship can be a financial support for poplar growers, i.e., farmers, with on time purchases and reasonable prices for their timber products. Especially, many limitations for harvesting wood from northern forests of the

Table 8 Cultivated areas and volumes of annual poplar harvest, with potential error percentages based on the results of field surveys and interviews in Kurdistan Province

Village	Area (ha)	Annual harvest (t)
Ghooreh darreh	2.00	5.0
Ghal'eh rutalleh	10.00	25.0
Zardeh kamar	6.00	6.0
Tavan kosh	1.00	0
Tiken	2.00	7.0
Vihaj	4.00	8.0
Average	4.17	8.5
Total	7,317.25	14,926.0
Error percentage	24.73%	10.66%

Note: The total number of villages in Kurdistan is 1,756.

country have been developed for use in related industries, for which a reliable and continuous source is poplar wood.

Conclusions

From field surveys it is clear that the dominant species in Hamedan and Kurdistan provinces is *Populus nigra*, while the dominant poplar species in Western Azerbaijan Province is *P. alba*. The areas of poplar plantations in these three provinces are 10,724, 26,055 and 7,317 ha, respectively. The estimated standing volume of poplar plantations are 8,131,098, 7,277,604 and 2,030,305 m^3, respectively. The annual harvest volume was 1.4 million m^3 in Hamedan, 0.7 million m^3 in Western Azerbaijan and 29.9 thousand m^3 in Kurdistan. The total volume of standing poplar in the three provinces was approximately 17.4 million m^3, suggesting a 30% increase in the volume of standing timber compared to the past decade. Poplar plantations have become desirable over the past decade, given the increasing number of industries using poplar wood. The potential annual harvest of poplar plantations in the entire country is about 10 million m^3. Based on the results from these three provinces, we estimate that, on average, about 45 m^3 timber per ha has been harvested.

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